Passage 2 Venus in transit

June 2004 saw the first passage （ ）, known as a ' transit （ ）', of the planet Venus across the face of the Sun in 122 years. Transits have helped shape （ ） our view of the whole Universe, as Heather Cooper and Nigel Henbest explain.

A

On 8 June 2004, more than half the population of the world were treated（ ） to a rare（ ） astronomical（ ） event. For over six hours, the planet Venus steadily（ ） inched（ ） its way over the surface of the Sun. This transit of Venus was the first since 6 December 1882. On that occasion（ ）, the American astronomer Professor Simon Newcomb led a party（ ） to South Africa to observe the event. They were based（ ） at a girl's school, where-it is alleged（ ）-the combined forces（ ） of three schoolmistresses（ ） outperformed（ ） the professionals with the accuracy（ ） of their observations.

B

For centuries, transits of Venus have drawn（ ） explorers and astronomers alike to（ ） the four corners of the globe（ ）. And you can put it all down to the extraordinary（ ） polymath（ ） Edmond Halley. In November 1677, Halley observed a transit of the innermost（ ） planet, Mercury（ ）, from the desolate（ ） island of St Helena in the South Pacific. He realised that, from different latitudes（ ）, the passage（ ） of the planet across the Suns disc（ ） would appear to differ. By timing the transit from two widely-separated locations（ ）, teams of astronomers could calculate the parallax（ ） angle（ ） -the apparent（ ） difference in position of an astronomical body（ ） due to a difference in the observers position. Calculating this angle would allow astronomers to measure what was then the ultimate（ ） goal: the distance of the Earth from the Sun. This distance is known as the 'astronomical unit'（ ） or AU.

C

Halley was aware that the AU was one of the most fundamental（ ） of all astronomical measurements. Johannes Kepler, in the early 17 century, had shown that the distances of the planets from the Sun governed（ ） their orbital（ ） speeds, which were easily measurable But no-one had found a way to calculate accurate distances to the planets from the Earth. The goal was to measure the AU; then, knowing the orbital speeds of all the other planets round the Sun, the scale（ ） of the Solar System（ ） would fall into place（ ）. However, Halley realised that Mercury was so far away that its parallax angle would be very difficult to determine As Venus was closer to the Earth, its parallax angle would be larger, and Halley worked out that by using Venus it would be possible to measure the Sun's distance to I part in 500. But there was a problem: transits of Venus, unlike those of

Mercury, are rare, occurring in pairs （ ） roughly （ ） eight years apart （ ） every hundred or so years. Nevertheless, he accurately predicted that Venus would cross the face of the Sun in both 1761 and 1769-though he didn't survive to see either.

D

Inspired （ ） by Halley’s suggestion of a way to pin down （ ） the scale of the Solar System, teams of British and French astronomers set out （ ） on expeditions to places as diverse as India and Siberia. But things weren' t helped by Britain and France being at war. The person who deserves most sympathy （ ） is the French astronomer Guillaume Le Gentil. He was thwarted （ ） by the fact that the British were besieging （ ） his observation site at Pondicherry in India. Fleeing （ ） on a French warship （ ） crossing the Indian Ocean, Le Gentil saw a wonderful transit-but the ships pitching and rolling （ ） ruled out （ ） any attempt at making accurate observations. Undaunted, （ ） he remained south of the equator （ ）, keeping himself busy by studying the islands of Mauritius and Madagascar before setting off （ ） to observe the next transit in the Philippines. Ironically （ ） after travelling nearly 50,000 kilometres, his view was clouded9 （ ） out at the last moment, a very dispiriting （ ） experience.

E

While the early transit timings were as precise （ ） as instruments would allow, the measurements were dogged （ ） by the black drop effect. When Venus begins to cross the Sun's disc, it looks smeared （ ） not circular （ ） - which makes it difficult to establish timings. This is due to diffraction （ ） of light. The second problem is that Venus exhibits （ ） a halo （ ） of light when it is seen just outside the Suns disc. While this showed astronomers that Venus was surrounded by a thick layer of gases （ ） refracting （ ） sunlight around it, both effects made it impossible to obtain accurate timings.

F

But astronomers laboured （ ） hard to analyse the results of these expeditions to observe Venus transits. Johann Franz Encke, Director of the Berlin Observatory （ ）, finally determined a value （ ） for the AU based on all these parallax measurements 153, 340, 000 km. Reasonably （ ） accurate for the time, that is quite close to today's value of 149, 597, 870 km, determined by radar, which has now superseded （ ） transits and all other methods in accuracy. The AU is a cosmic （ ） measuring rod （ ）, and the basis of how we scale （ ） the Universe today. The parallax principle can be extended to measure the distances to the stars. If we look at a star in January -when Earth is at one point in its orbit-it will seem to be in a different position from where it appears six months later. Knowing the width of Earth's orbit, the parallax shift lets astronomers calculate the distance.

G

June 2004s transit of Venus was thus more of an astronomical spectacle（ ）than a scientifically important event. But such transits have paved（ ） the way for what might prove to be one of the most vital breakthroughs in the cosmos-detecting Earth-sized（ ） planets orbiting other stars.